# HCAT/JCAT Program Review Meeting



# Cadmium Alternatives for High-Strength Steel JTP – Phase II



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## **Project Overview**



### **Objective**

Assess DoD-selected cadmium alternatives in accordance with the DoD-approved Joint Test Protocol (JTP) for both traditional plating and brush plating of HSS applications (JTP available at <a href="https://www.jgpp.com">www.jgpp.com</a> – JCAT links)



### **Approach**

- Three-phased approach (JTP Test Matrix)
  - Phase I (preliminary requirements focused)
  - Phase II (overall performance focused)
  - Phase III (fatigue testing focused)
- Down-selection of candidates for further testing after each phase of testing is complete (Phases I & II)

## **Project Team Members**



- AFRL Dr. Elizabeth Berman
- CTC Ms. Tamera Crocco and Ms. Leanne Debias
- NAVAIR Mr. Steve Brown
- Boeing Mr. Joe Osborne
- ARL Mr. Brian Plosankis
- WMTR Mr. Jay Curry
- Hill AFB Mr. Nate Hughes
- Alumiplate Mr. Gus Vallejo
- Marshall Laboratories Mr. John Marshall



# Phase I Overview and Selection Process



#### **Coatings tested during Phase I**

- Traditional plating (primary coatings):
  - Sputtered Aluminum (Marshall Labs)
  - Electroplated Aluminum (Alumiplate)
  - LHE Zn-Ni (Dipsol IZ-C17)
  - Acidic Zn-Ni (Boeing, Seattle)
  - Sn-Zn (Dipsol)

#### **Tests Conducted**

- Hydrogen Embrittlement
- Re-embrittlement
- Adhesion

#### Brush plating (repair coatings):

- Brush Zn-Ni (SIFCO 4018)
- Brush Sn-Zn (LDC 5030)
- Spray Aluminum-ceramic (Sermetel 249/273)



#### **Down-Selection Process to Phase II**

- WebEx Teleconference to review results
- Team Members voted on Phase II candidates Completed
   Jan 06

### **Alternative Selection - Phase I**



#### **Coatings selected for Phase II**

- Primary test coatings
  - LHE Zinc-Nickel (Dipsol IZ-C17)
  - Electroplated Aluminum
  - Sputtered Aluminum
  - Controls Cadmium and IVD AI
- Repair test coatings
  - Aluminum-Ceramic Repair Coating (Sermetel)
  - Zinc-nickel brush repair
  - Tin-Zinc brush repair
  - Control Cd Brush

All Phase II testing methods will be performed according to the procedures and requirements in the JTP



# **Phase II Tests**



Test Category	Test	Testing Facility	
	Appearance	CTC (POC – Leanne Debias)	
General Properties	Throwing power and alloy composition uniformity	CTC	
	Strippability	NAVAIR (POC – Steve Brown)	
	Galvanic potential	ARL (POC – Brian Plosankis)	
Adhesion	Bend adhesion	NAVAIR	
Adnesion	Paint adhesion	NAVAIR	
	Unscribed NSS* (bare)	ARL	
	Scribed NSS* (bare)	ARL	
Corrosion	Galvanic corrosion resistance	ARL	
Corrosion	Fluid corrosion resistance	ARL	
	Scribed, painted salt spray	NAVAIR (paint), ARL (test)	
	Scribed and unscribed SO <sub>2</sub> salt spray	NAVAIR	
	Run-on/Break-away torque	WMTR (POC – Jay Curry)	
Lubricity	Torque-tension & torque-tension of corrosion- exposed fasteners	WMTR	
	Appearance & Thickness	CTC	
Bonorobility.	Bend adhesion	ARL	
Reparability	Paint adhesion	ARL	
	Scribed and unscribed salt spray	ARL	
Quality Assurance	uality Assurance Hydrogen embrittlement – notched bar		



## **Status of Phase II Testing**

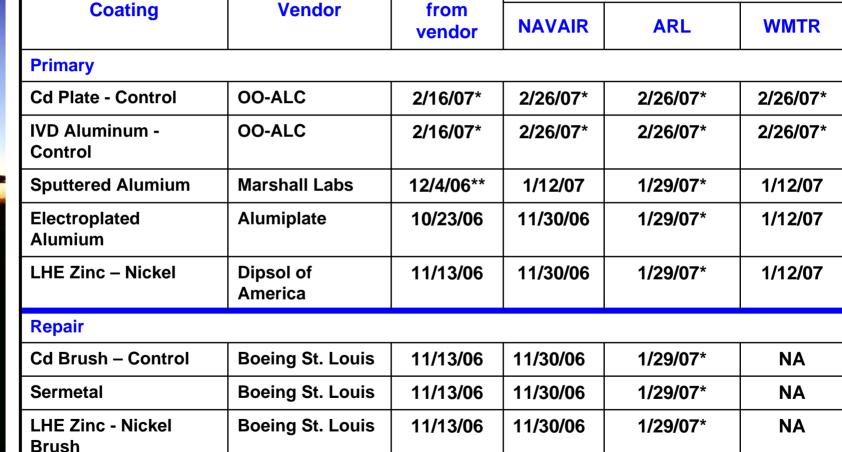
Received



In Testing

1/29/07\*

NA



11/13/06

11/30/06

**LHE Tin - Zinc Brush** 

**Boeing St. Louis** 

<sup>\*</sup>Anticipated dates

<sup>\*\*</sup> Flat panels only

# Phase II Down - Selection Process



- Down-Selection Test Report to be issued for AFRL/JCAT review (JUL 07)
- WebEx teleconference to review the Phase II Test Report (AUG 07)
- Team Members to Vote on Candidates for Inclusion in the Phase III effort
  - Any alternatives with clear deficiencies in a number of test categories will be eliminated from Phase III testing
  - If all Phase II test results are acceptable, then all primary and repair coatings will be tested in Phase III



# **Phase III Testing**



### Phase III Testing Methods

- Primary Coatings
  - Rotating beam fatigue smooth bar
  - Rotating beam fatigue notched bar
  - Bend adhesion (quality assurance)
  - Hydrogen embrittlement (quality assurance)
- Repair Coatings
  - Rotating beam fatigue smooth bar

#### Phase III Test Facilities

- All fatigue testing will be performed at WMTR
- NAVAIR will perform the quality assurance testing



#### **Timeline**



**End Date** 

Jan-06

Sep-08

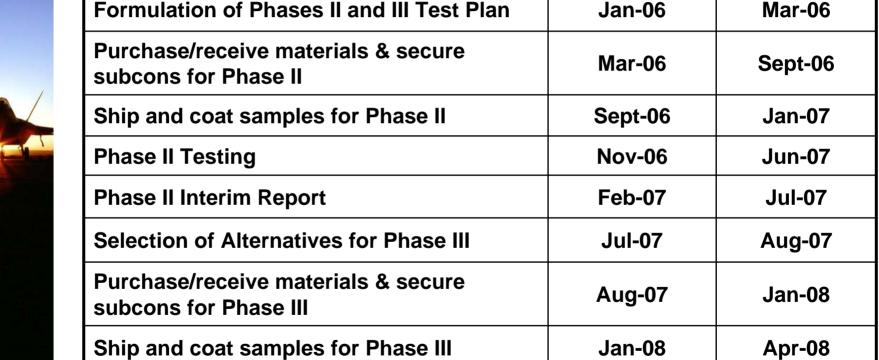
**Nov-08** 

**Start Date** 

**Nov-05** 

Apr-08

Aug-08



**Activity** 

Selection of Alternatives from Phase I



Phase III Testing

**Final Technical Report (JTR)** 

## **Summary**



- Selected alternatives from Phase I have been coated
- Alternatives are currently in Phase II testing (CTC, NAVAIR, ARL, WMTR)
- The Phase II Interim Report is planned to be complete in JUL 07
- A web-ex teleconference will be held to review the report and select alternatives for Phase III – AUG 07
- Phase III is planned to begin in AUG 07



# **Back-Up Slides**



# **Testing Procedures**



# Description of Testing Methods U.S. AIR FORCE

#### General properties (primary coatings)

- Appearance visual exam
- Throwing power
  - Test fixture surrounds panel, with one access slot
  - Fixture + panel is placed in solution at 3 different orientations
  - Uniformity of coating is measured at 3 locations on each panel
- Strippability
  - Specimens are stripped by vendor-recommended method
  - Half of specimens are tested
  - Remaining specimens are recoated and tested
    - Hydrogen Embrittlement
    - Adhesion
- Galvanic Potential
  - Three types of measurements are performed over 5 days: open circuit potential measurement, electrochemical impedance spectroscopy, and tafel analysis





### Adhesion (primary coatings)

- Bend adhesion
  - Specimen is bent back and forth through 180° until the coating and/or substrate ruptures
- Wet tape paint adhesion
  - Primers are applied to test panels (14 day cure)
    - MIL-PRF-85582 Type I, Class C1
    - MIL-PRF-85582, Type I, Class N
    - MIL-PRF-23377 Type 1, Class C
  - Panels are immersed in distilled water at following conditions:
    - 23°C for 24 hours
    - 49°C for 96 hours
    - 65°C for 168 hours
  - Perform tape adhesion according to ASTM D3359, Method B





### Corrosion (primary coatings)

- Unscribed and Scribed Neutral Salt Spray (bare)
  - Bare panels exposed to a 5% NaCl solution sprayed at 35°C, until coating failure
- Galvanic corrosion resistance
  - Components of test assemblies: 2024 or 7075 Al test block, coated with MIL-PRF-85582, Class 1, Type N, test washer (4 alloys), nuts, bolts, anodized washers
  - Test assemblies are exposed to salt fog for 168 hours and cyclic corrosion for 336 hours
- Fluid corrosion resistance
  - Immerse panels in specified fluid at 100°F for 7 days
  - Test fluids: sea water, deicers, paint removers, cleaners, lubricants (14 total)





### Corrosion (continued)

- Scribed Painted Neutral Salt Spray
  - Test panels are primed with
    - MIL-PRF-85582 Type I, Class C1
    - MIL-PRF-85582, Type I, Class N
    - MIL-PRF-23377 Type 1, Class C
  - Test panels are exposed to 5% NaCl solution at 35°C for 3000 hours or until red rust
- Scribed and Unscribed SO<sub>2</sub> Salt Spray
  - Unpainted panels and scribed, painted panels (same primers as above)
  - Expose to 5% NaCl and SO<sub>2</sub> gas IAW ASTM G85 A4 until coating failure (red rust)





#### Lubricity (primary coatings)

- Run-on/Breakaway Torque
  - Record maximum locking torque after 2 complete turns from point where the top of the nut is flush with the end of the bolt
  - Breakaway torque is measured during removal of the nut
  - Measure for 15 lock/breakaway cycles and examine at 10x for thread damage
- Torque Tension
  - Measure torque and induced load with test fixture for the range of 30%-60% of the bolt UTS
  - Repeat for a total of 5 cycles
- Torque Tension of corrosion-exposed fasteners
  - Assemble bolts/nuts/washers onto an Al test block
  - Torque to 60% of UTS for bolt and exposed to cyclic corrosion for 28 days
  - Measure breakaway torque and compare to unexposed set







- Initial qualification coating applied to bare substrate and tested
- Final qualification candidate primary coating of choice is abraded to generate a bare area and then repaired with a brush plating
- Testing Methods
  - Appearance visual exam
  - Bend adhesion bend specimen back over itself until rupture
  - Thickness cross-section and microscopy
  - Scribed and unscribed salt spray (bare) until failure
  - Paint adhesion apply primers, immerse in distilled water at same temps/times as primary coatings, and perform cross-hatch adhesion according to ASTM D3359, method B
- Quality assurance HE testing to compare to Phase I

